# Studies on the Radiation Breeding in the genus *Mentha*

# (XII) Variation in Quantitative Characters of $X_2$ plant after Hybridization and Irradiation in Mint

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## Introduction

In crop plants most of the productive traits are quantitative characters controlled by multifactorial or polygenic systems. That irradiation can be used a a tool for creating new variability in polygenic traits has been demonstrated by a number of workers.

Furthermore, there are possibilities for a combination of cross breeding with induced mutations. As one of them, induction of mutations in $F_1$ seeds of a hybrid population may be useful because it means an additional increase of variability. But, up to date there is little experimental evidence of such an approach.

The present investigation was undertaken to make a comparative assment of irradiation effects on the amout of induced variability in several quantitative characters of two mint species and their hybrids. The effects of irradiation on the variation of some quantitative characters of $X_2$ population are described in this report.

## Material and Methods

In 1965 hybrid seeds were obtained from a cross between two species of mentha, e.g. *M. arvensis* and *M. spicata*. After the dormant seeds of the two parental species and their hybrids were stored in a desiccator over saturated sodium chlorate, these seeds were treated with gamma rays from a $^{60}$Co source. The moisture content of the seeds was then approximately 15 percent. The irradiated seeds were planted in the nursery. After about one month the seedlings were transplanted into the field. Four early appearing inflorescens were harvested from each $X_1$ plant and analyzed for inflorescens fertility. From each $X_1$ inflorescens five seeds were removed and bulked to grow $X_2$ generation plants.

On harvesting one inflorescens from individual $X_2$ plants, data was recorded on seed size and endsperm quality. Measurement of length and breadth of five seeds from each plant of each population was taken. Furthermore, ten seeds from each plant of the same populations were analyzed for the destruction of endosperm by 1.8% KOH solution. The degree of destruction was determined with the index ranging from 0 to 6; namely,

0. . . . Cut surface of endosperm being unchanged
1. . . . Cut surface being swelled
2. . . . Cut surface being destructed and swelled wholly
3. . . . Destructed to show irregular shape
4. . . . Destructed as if a piece of cotton
5. . . . Dissolved and semi-transparent
6. . . . Nearly transparent.

The data for both the characters were analyzed separately by an appropriate analysis of variance. The pertinent mean squares and parameters estimated in each analysis were as follows;

| Source of variation | Mean square | Parameters estimated |
|---|---|---|
| Among plants | $M_1$ | $\sigma_{s^2} + \sigma_{pl^2}$ |
| Among seeds of same plant | $M_2$ | $\sigma_{s^2}$ |

where $\sigma_{s^2}$ is the component of variance due to differences among seeds on the same plant, $\sigma_{pl^2}$ the component of variance due to differences among plants in the same population, and $\gamma$ the number of seeds measured in one plant. Hence, $\sigma_{pl^2}$ was estimated from $(M_1-M_2)/\gamma$. The amount of induced genetic variance, Vig, was estimated by subtracting $\sigma_{pl^2}$ (control) from $\sigma_{pl^2}$ (treated), where $\sigma_{pl^2}$ (control) is composed of genetic variance due to inpurity of original seeds and spontaneous mutations, and environmental variance.

## Results

The data on the fertilities of $X_1$ inflorescens was presented in Table 1. It is clear that *M. spicata* is less affected than *M. arvensis* and hybrids.

Table 1. Fertilities of $X_1$ inflorescens after seed irradiation of different populations

| | *M. arvensis* | | Hybrids | | *M. spicata* | |
|---|---|---|---|---|---|---|
| | control | treated | control | treated | control | treated |
| No. of analyzed inflorescens | 200 | 200 | 177 | 200 | 200 | 200 |
| Mean fertility (%) | 93.7 | 77.2 | 93.8 | 77.9 | 93.8 | 82.3 |
| Relative figure | 100 | 82 | 100 | 83 | 100 | 88 |

Figure 1 demonstrates the distribution of length and breadth of seed of each population. The upper three figures represent nonirradiated while the lower three represent irradiated populations. From the figure it is apparent that the range of distributions are wider in the irradiated than in the nonirradiated populations

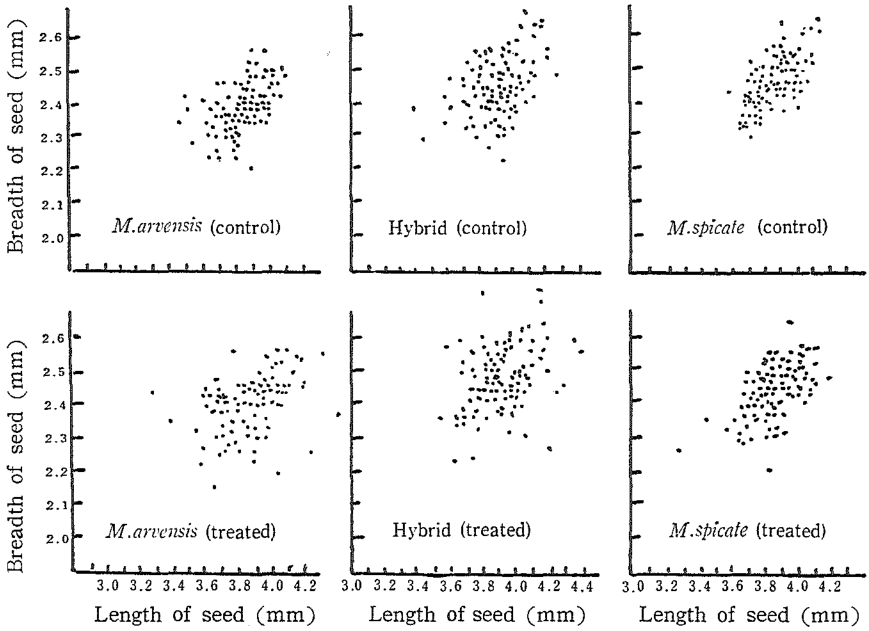


Fig 1. Distribution of length and breadth of seed in $X_2$ populations

with the exception of irradiated hybrid population. The result of the analysis of variance for length and breadth of seed of each population is shown in Table 2. The data indicate that the mean value of each treated population was almost the same as that of nonirradiated control population. All of the mean squares among plants ($M_1$) were significantly greater than the corresponding mean squares within plant ($M_2$). Moreover, the mean squares among plants in treated populations were greater than in controls for both length and breadth. The estimated variance

Table 2. Mean, mean squares and parameters estimated from the analysis of variance for seed-size character studied in $X_2$ plants

(1)

| Length of seed | | | | | | |
|---|---|---|---|---|---|---|
| | *M. arvensis* | | Hybrids | | *M. spicata* | |
| | control | treated | control | treated | control | treated |
| Sample size | 100 | 108 | 110 | 105 | 108 | 105 |
| Mean (mm) | 6.85 | 6.85 | 6.87 | 6.89 | 6.84 | 6.84 |
| Mean square $M_1$ | 0.1030** | 0.1877** | 0.1127** | 0.1467** | 0.0805** | 0.1008** |
| 〃 $M_2$ | 0.0335 | 0.0301 | 0.0175 | 0.0260 | 0.0234 | 0.0257 |
| Estimated variance among plants | 0.0139 | 0.0301 | 0.0175 | 0.0241 | 0.0114 | 0.0150 |
| Induced genetic variance | — | 0.0162 | — | 0.0066 | — | 0.0036 |

(2)

| Breadth of seed | | | | | | |
|---|---|---|---|---|---|---|
| | *M. arvensis* | | Hybrids | | *M. spicata* | |
| | control | treated | control | treated | control | treated |
| Sample size | 100 | 108 | 110 | 105 | 108 | 105 |
| Mean (mm) | 3.38 | 3.39 | 3.43 | 3.47 | 3.46 | 3.45 |
| Mean square $M_1$ | 0.0248** | 0.0422** | 0.0398** | 0.0475** | 0.0242** | 0.0338** |
| 〃 $M_2$ | 0.0109 | 0.0107 | 0.0138 | 0.0111 | 0.0114 | 0.0111 |
| Estimated variance among plants | 0.0031 | 0.0067 | 0.0052 | 0.0072 | 0.0025 | 0.0045 |
| Induced genetic variance | — | 0.0036 | — | 0.0020 | — | 0.0020 |

**=significant at 1% level

among plants in the treated population shows the same tendency as the mean square among plants. Concerning induced genetic variance, the value was larger in *M. arvensis* than in *M. spicata* and the hybrid for both length and breadth.

Table 3 presents the result of the analysis of variance for endosperm quality. The data showed that the mean of all the irradiated populations was greater than that of the control. The difference of the mean value between the irradiated and control populations was statistically significant for *M. arvensis* and the hybrid, whereas a significant difference was not found for *M. spicata*. The variance of irradiated populations was more than the control. In this case also, all the mean squares among plants ($M_1$) were significantly greater than the corresponding mean squares within plant ($M_2$).

Table 3. Means, mean squares and parameters estimated from the analysis of variance for endosperm quality studied in $X_2$ plants

| Quality of endosperm | | | | | | |
|---|---|---|---|---|---|---|
| | *M. arvensis* | | Hybrids | | *M. spicata* | |
| | control | treated | control | treated | control | treated |
| Sample size | 99 | 110 | 118 | 110 | 108 | 107 |
| Mean | 3.70 | 4.20 | 2.50 | 3.25 | 1.70 | 1.85 |
| t-test | * | | * | | * | |
| Mean square $M_1$ | 2.317** | 3.511** | 5.395** | 6.441** | 3.110** | 4.109** |
| 〃 $M_2$ | 0.671 | 0.725 | 0.516 | 0.401 | 0.584 | 0.464 |
| Estimated variance among plants | 0.1646 | 0.2786 | 0.4879 | 0.6040 | 0.2516 | 0.3726 |
| Induced genetic variance | — | 0.1140 | — | 0.1161 | — | 0.1210 |

—=no significant *=significant at 5% level **=significant at 1% level

## Discussion

From the results of present investigation it can be seen that the mean value of the irradiated population with respect to seed size character was almost the same as that of the nonirradiated control. The variance of the irradiated population increased (Table 2). On the other hand, for endosperm quality the irradiated populations showed increase in the mean value as well as variance.

These findings are in agreement with those of many workers (GREGORY, 1955; OKA et al., 1958; MATSUO and ONOZAWA, 1960; YAMAGUCHI, 1962), who noticed increase in variance following irradiation. They are found that in the irradiated populations there was no appreciable change in mean value indicating that in polygenes the mutation with + and − effect occurred equally frequently. On the other hand, BHATIA and SWAMINATHAN (1962) in bread wheat have observed the decrease in the mean value of the population and the consequent increase in the frequency of occurrence of plants having value on the negative side of the mean. They suggested that mutations with the detrimental effect occurred more frequently.

The present findings have suggested that a direction of the occurrence of polygenic mutations depends upon the specific character study under and the material used. One reason for this could be that in some varieties, for instance *M. arvensis,* selection against gametes with unfavourable changes is not rigorous than in others like *M. spicata.* The data on seed fertility in $X_1$ inflorescens indicate that *M. spicata* is more radioresistant than *M. arvensis* and the hybrids (Table 1). However, for endosperm quality the induced genetic variance was smaller in *M. arvensis* and the hybrids than in *M. spicata.*

The expected relation of the variance in advanced generations following hybridization and irradiation is given by the following hypothesis (GREGORY, 1955);

$$\sigma_g^2 F_2X_2 = (\sigma_g^2 P_1X_2 + \sigma_g^2 P_2X_2)/2 + \sigma_g^2 F_2$$

where $\sigma_{g^2}$ is the genetic variance of the character measured; $F_2$ $X_2$ is a hybrid population in the $F_2$ generation treated with radiation in the $F_1$ generation; $P_1$ $X_2$ and $P_2$ $X_2$ are the parents of the hybrid in second generation following irradiation. The data in Table 2 showed that for length and breadth of seed the mean of induced genetic variances in two parental populations was more than the induced genetic variance in hybrids. But, for endosperm quality such a difference was not found. Hence, the above hypothesis held good for endosperm quality, not for seed size character. The findings obtained for the latter agrees with those of GREGORY (1956). He has reported that there is no experimental evidence to contradict the hypothesis that the irradiation might destroy some of latent variance in the $F_1$ generation. GUSTAFSSON (1954), however, presented evidence that hybrids are naturally more mutable than pure breeding lines. Due to Mendelian segregation $F_2$ plants consist of various genotypes. In view of this fact, the above phenomena can be explained by assuming that manifestation of mutated characters could be modified by background genotypes. By using the isogenic lines obtained following backcrosses, TSAI (1961) recognized that the genes for early maturity interacted differentially with the genetic background.

These results suggest the importance of the selection of genetic background favorable for the induced mutants in mutation breeding.

## Summary

The present paper describes some aspects of inducing genetic variation of polygenically controlled characters following the irradiation of two mint species and their hybrids. The data for the characters studied in $X_2$ generations were analyzed by appropriate analysis of variance. In all the cases, the mean value of the irradiated population with respect to seed size character was almost the same as that of the non-irradiated control, while the variance of the irradiated population increased. On the other hand, for endosperm quality the irradiated populations showed increase in the mean value and the variance.

The results obtained in the present experiment suggest that back-ground genotypes played an important role in the manifestation of mutated characters.

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# ハッカ属植物の放射線育種に関する研究
# （第12報）ハッカ交配種子の照射によって誘発された量的形質の変異

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放射線照射によって $F_1$ 種子はその後代に遺伝変異をますことが予想されるので，育種上有用な方法と考えられる．そのために，ハッカ属の *M. arvensis* と *M. spicata* の気乾種子およびそれらの間の交配種子に $^{60}$Co $\gamma$線を 20 KR 照射した．$X_2$ 植物体における種子について種子の長さと幅の測定および胚乳崩かい度の調査を行なった．

種子の長さと幅および胚乳崩かい度の個体間分散は放射線照射によって増加した．種子の長さと幅に関して，何れの集団とも平均値には照射の影響が認められなかった．胚乳崩かい度に関して *M. arvensis* と雑種では平均値の増加があったが，*M. spicata* では平均値の変化が認められなかった．また種子の長さと幅では放射線が $F_1$ の潜在的変異をいくらかこわすように働き，胚乳崩かい度では放射線による誘発変異と遺伝子の分離による変異とがほぼ相加的であった．

以上の結果は，突然変異形質の発現に遺伝背景が重要な役割を演じていることを示唆している．